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ABSTRACT

The activities of the Asian Regional Institute for School Building Research are described (studies conducted, contracts, development group work). Technical notes are presented concerning high-rise school buildings in Asian urban areas and related cost implications; the following factors are considered--(1) demand for space in urban areas, (2) minimum space requirements of the school site, (3) effect of height on cost of the building, (4) limitations on the height of the school, (5) when to build high-rise schools, and (6) allocation of land for schools. Also included are abstracts of 16 journal articles concerned with various aspects of educational buildings. (FS)

ED037913

Asian Regional Institute for School Building Research

Sponsored by Unesco

BUILDINGS FOR EDUCATION

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Vol. 2 No. 2 June 1968

ARISBR

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I. QUARTERLY REVIEW

The Institute's Activities, April - June 1968

Study on the Design of Cyclone-Resistant Schools in East Pakistan:

A Mission to East Pakistan comprising the Institute's Research Architect, Mr. D. J. Vickery, the Development Group Advisor, Mr. C. E. Finney and a specially-appointed Unesco Consultant Structural Engineer, Mr. Felix Kulka, visited East Pakistan in March and April. After a study involving indentification of those areas subject to severe tropical cyclones and collection of statistical material, a Report was presented to the Director of Public Instruction, East Pakistan, proposing a primary school construction programme for the 4th Five-Year Plan period.

Mr. C. E. Finney, Development Group Advisor, has now returned from East Pakistan after discussing the Report and its implications with the education authorities. During the visit advice was received from Paris of the possibilities of a source of financial aid for the development of 5 prototype cyclone-resistant schools. It was decided that ARISBR would develop concept sketches for these prototypes for use by Unesco, Paris, in further developing the source of outside assistance.

Design of Teaching Spaces:

Work on the design of Home Economics Laboratories, and Biology and Physics Laboratories for second-level schools in the Asian Region has now been completed and Studies No.1, 2 and 4 are being prepared for publication.

The study of the design of physics laboratories is now to be extended through the medium of a field trial in Dharmapala School near Colombo; physics tables designed by the Institute are to be installed in a building gifted to the Institute by Messrs Arcon Ltd., Singapore. At the completion of the study of these tables in use, opportunity will be taken in 1969 to carry out illumination and thermal comfort studies in this building.

The field trial of the Institute's hexagonal chemistry teaching tables continues in Homagama Secondary School, near Colombo, and substantial modifications have now been made to the tables. Experience with these studies has shown the value of field trials of furniture and equipment in prototype before the designs are used for mass production.

Thermal Comfort Study:

The thermal comfort study to establish an index to thermal comfort for acclimatized Ceylonese children continues in Walhaputenne School, some 120 miles from Colombo and in Ananda College, Colombo. Some 60 children are participating in the first phase of study, which will be completed in September.

Cost Studies:

Work continues on the studies of cost and space utilisation in schools of Afghanistan, India and Singapore. The Institute's Cost Expert, Mr. R. H. Sheath, has also been engaged in a study on the costs of the cyclone-resistant school programme in East Pakistan and is currently working on a study of the per place cost of high-rise schools. The Technical Notes in Section II of this issue of Buildings for Education indicate the Institute's preliminary ideas on this subject.

Contracts:

A contract for the study of high multi-storied schools commenced by the Atelier Akitek, Singapore Polytechnic, is now entering its second phase. The architects concerned have completed a study of high-rise schools in Hongkong and Singapore and the results of a questionnaire issued to those responsible for the administration of high-rise schools in the Asian Region are being analysed.

At the Central Building Research Institute, Roorkee, equipment is now being manufactured for the measurement of luminance and availability of daylight in the Asian Region. Installation of the equipment will take place in July and will be followed by one year's readings.

Development Group Work:

The Institute's Development Group Advisor has visited Iran and Afghanistan in connection with the formation of Development Groups in these States and has started the formation of a Development Group for the design of cyclone-resistant schools in East Pakistan (see para 1 above). The architect member of the Group at the outset will be drawn from the staff of the University of Engineering and Technology, Dacca, pending final approval. The East Pakistan Government has also expressed a desire for a Unesco Associate Expert Architect to assist on this Development Group.

Documentation:

The Institute's Documentalist undertook a Mission in the Region, from 25th April to 6th June. During the course of this Mission she visited Madras, Calcutta, Kathmandu, Dacca, Bangkok, Phnom-Penh, Singapore and Kuala Lumpur. The mission was successful in confirming that the Institute's publications are now reaching the majority of relevant departments and institutions in this part of the Region and in stimulating interest in ARISBR's publications among newly contacted organisations in the countries concerned. The Documentalist also collected plans and reports for the work of the other professional staff members of the Institute, particularly in relation to cost studies and development group work.

Visitors:

During the three months covered by this issue of Buildings for Education, the Institute has been visited by:

Mr. Masa Hiko Seki,
Deputy Chief,
General Affairs Section,
Japanese National Commission for Unesco,
Japan.

Professor Haliwell,
Professor of Chemical Education,
Norwich, (Nuffield Chemistry Project).

Mr. Masunori Hiratsuka,
Director-General,
National Institute for Educational Research
Centre for Educational Studies in Asia,
Japan.

Dr. Kihei Koizumi,
Head of Section for Educational Research
Workshops in Asia,
NIER,
Tokyo,
Japan.

II TECHNICAL NOTES

THE COST IMPLICATIONS OF HIGH-RISE SCHOOL BUILDINGS IN URBAN AREAS

Summary

It is often quoted that the population of the Region will double itself by the year 2000 and that this expansion of population will bring with it an unprecedented demand for living space.

Invariably this demand for living space in the cities or urban areas, due to high densities of population, leads to high-rise buildings and brings with it the problem of establishing the economical height to build.

For a commercial development concerned with obtaining an adequate return on an investment, it is particularly important that the most effective use be made of land and buildings and it is quite usual for several schemes to be prepared, costed and evaluated.

However with school building the complete range of factors concerning the economical use of land is not always considered. This may be due in part to the system of educational zoning whereby the size of the school is more or less fixed by the school-going population within the zone and partly by regulations stating that schools shall have a certain fixed area of land. This latter regulation does not always stipulate the size of the school by numbers of students and often includes a substantial area of land for sports. If land is scarce it is hard to justify the reservation of land for playing fields for intermittent use by school children who constitute a relatively small proportion of the population the area. On the other hand, it is not uncommon to find schools in the cities on sites which are too small, resulting in overcrowding of the play area and (perhaps more serious) presenting a traffic hazard to the students coming and going from the school.

It would seem that the time has come to fix minimum space standards of land-use as minimum space standards have been fixed for teaching spaces and thus to ensure that all schools have adequate site areas in order to avoid either provision of spatially wasteful sites or unnecessarily small sites.

When minimum space requirements have been established it will then be possible to consider the most economical development of the site in terms of land cost, building cost and numbers of students.

1. *The Demand for Space in Urban Areas*

It is generally accepted that in urban areas the school of the future will need to be housed in high-rise buildings, but on what is this acceptance based? Often it is quoted that it is the high cost of land which forces the buildings to go up in height, but at what point does this occur and when is it more economical to build two, three or six storeys?

It is the demand for space in localities of high density of population that creates the need for high-rise buildings. In certain instances, the high cost of land may lead a developer to build high-rise buildings and thus obtain more floor space so that he can obtain an adequate return on his investment; but in "high class" residential areas, where the land is invariably at a premium, a developer may be more concerned with privacy than floor space and thus these areas despite the high land cost will have a low density of population.

What then constitutes high density of population? It is possible to provide all dwellings in two-storey building for a nett density of population not exceeding 70 persons per acre (=4046m^2). In a residential area which has predominately two-storied buildings it may be said that it is not "good architectural manners" to build a high-rise school building; yet in a theoretical hexagonal catchment area with following features:

radius	= 1.25 miles (2km)
area	= 3456 acres (14.00km^2)
population density	= 70 per acre(17,300 per km^2)
potential school population	= 48,000

schools of 3,000 pupils and upwards will be normal and these schools will be in close proximity to one another.

With such high densities of schools it is apparent that the area of land available for each school would be small. It is improbable, for instance, that land would be available for each school to have its own football pitch or sports oval. On the other hand, the solution to the land situation should not mean that the school grounds becomes only a square of asphalt.

2. *Minimum Space Requirements of the School Site*

Since the area of land available will influence both the total (or capital) cost of the school and thus the decision to build a high-rise school, it becomes important to determine the minimum area of land required per pupil place for each type of school.

Land requirements for schools come under four broad headings:

i) for the buildings themselves;
ii) for space about the buildings;
iii) for physical exercise and external activities of the school;
iv) for play and assembly areas.

i) The area of land required for the buildings will reduce proportionately with the number of storeys but as there will be some single-storey buildings even with high-rise schools (*e.g.* workshops may be located apart from the main building) it is suggested the 20% should be added to the building area to allow for this.

ii) The area of land around the building for light and air, setback of the building from the boundaries, access-paths and car-parks etc. is also variable and will depend not only on the size of the school, but also on the height and number of building blocks and width of surrounding roads etc. With skilful layout the space about or between the buildings can be used for gardens or recreation areas during recess periods or for assembly areas and so increase the minimum space available for these activities. It is suggested that provision for space about the building should be made on a sliding scale of 50% of the building area for a single-storey building dropping to 25% of the building area for four-storey buildings and above.

iii) The need for physical exercise can be satisfied with callisthenics and games requiring small areas of land, such as volleyball and basketball. Assuming 80% utilisation, a single volleyball court for example will provide exercise for 12 classes. An area of 1.66m^2 per pupil place will provide sufficient area for a basketball court and space for physical training for a school of between 480 and 640 pupils.

For a similar-sized school an area of approximately 100m^2 for a secondary school and 50m^2 for a primary school is required for outside science activities (science garden).

iv) An area of 1.5m^2 per pupil place for recreational purposes during the recess periods should be provided in addition to the above areas.

Table I sets out the minimum area of land per pupil place which should be provided in an urban school. As it is unlikely that the urban school will have less than 640 students minimum total areas need not be set down. These land areas are also shown in graphical form in Graph 1.

TABLE I - MINIMUM AREA OF LAND PER PUPIL PLACE IN SQUARE METRES

Unit	*Primary*	*Secondary*	*Comprehensive*
Buildings[1/]	*1.30*	*3.00*	*5.00*
Physical training	*1.66*	*1.66*	*1.66*
Science garden	*0.10*	*0.30*	*0.20*
Recreation area	*1.50*	*1.50*	*1.50*
Space about buildings	Allow 50% of the area given for Buildings for single-storey buildings; 38% for 2-3 storey buildings and 25% for 4-storey buildings above.		

Thus, the area of land required for a four-storey second-level[2/] *general school of 1280 students would be:*

Buildings	(3.00 ÷ 4) + 20% x 1280	=	1152 m^2
Space about buildings	25% 1152	=	288
Physical Training	1.66		
Sc.garden	0.30		
Recreation area	1.50 = 3.46 x 1280	=	4428
			5868 m^2

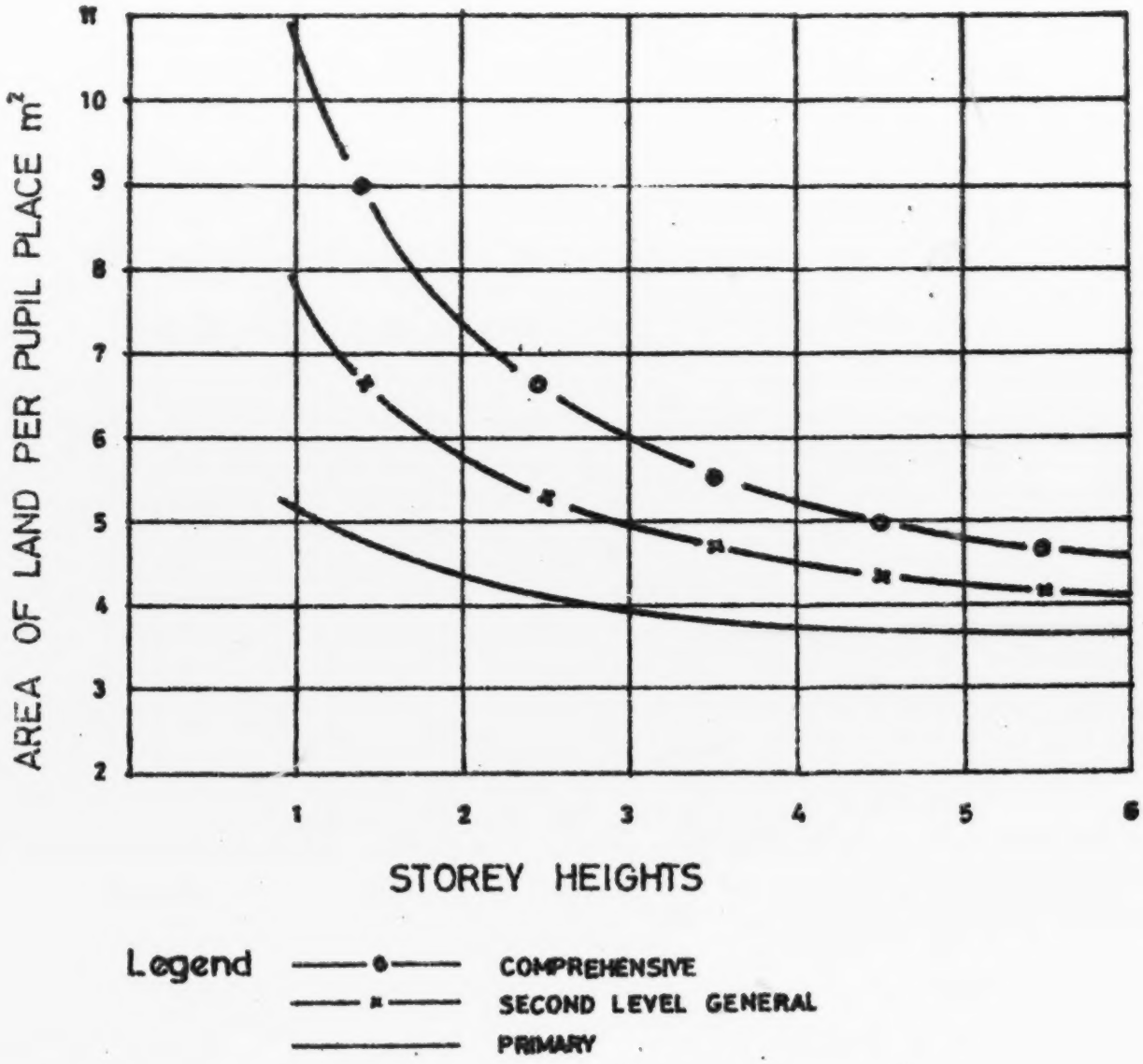
(Approx 1$\frac{1}{2}$ acres)

[1/] *These areas per place for buildings are those recommended by Unesco in its Asian model of educational development; perspectives for 1965-80. Paris, 1966.*

[2/] *"Second-level" is used by ARISBR and Unesco to include all kinds of secondary schools.*

GRAPH - 1

MINIMUM AREA OF LAND PER PUPIL PLACE



3. *Effect of Height on Cost of the Building*

There seems to be no doubt that the cost of the building increases with the height, and the cost studies undertaken by ARISBR in some countries of the Region confirm this. This establishment of cost indices reflecting the additional costs brought about by the increase in the height of the building is not easy mainly because of the difficulty in obtaining a sufficient number of similar types of buildings of varying storey heights.

One approach to the study of cost relationship and storey heights may be to conduct a theoretical study based on common assumptions with regard to specifications, pricing, type and

size of school. The results of the study would need to be applied with caution as it is seldom possible to represent all architectural solutions in the assumptions. Nevertheless it is considered that the cost indices arising from a study of this nature will be sufficiently reliable at the planning stage to arrive at a basic decision on whether or not to build high-rise schools.

Some of the factors influencing this higher cost are:

a) Cost of additional builders' plant and equipment - cranes, scaffolding etc.
b) Additional labour and insurance costs for high buildings.
c) Extra costs for utility services, increase in size of pipes, pumping equipment, storage tanks, transformers, etc.
d) Additional stairways and more stringent requirements regarding means of escape in case of fire.
e) Extra costs brought about by increased loads on foundations and in the structural design to resist wind pressures.

It may be possible by using an industrialised building system or by careful design to reduce the cost of the multi-storey building to a point where there is no significant difference in cost at the various floor levels. One other factor to be taken into consideration is that there is an indication that the cost per pupil place tends to decrease as the school population increases, although this decrease falls off rapidly above 400 or 500 students. This may well mean that although the cost per square metre increases with the height of the building, the drop in the cost per pupil place may offset some or all of this additional cost.

4. *Limitations on the Height of the School*

The single factor which has the greatest influence on the cost of the high-rise school building is that of vertical circulation. At what point are lifts necessary? The cost of providing lifts in the normal type of secondary school in the Region may add between 15% - 20% to the cost per pupil place. The cost per pupil place of installing lifts will vary according to the number of classrooms on each floor served by the lifts.

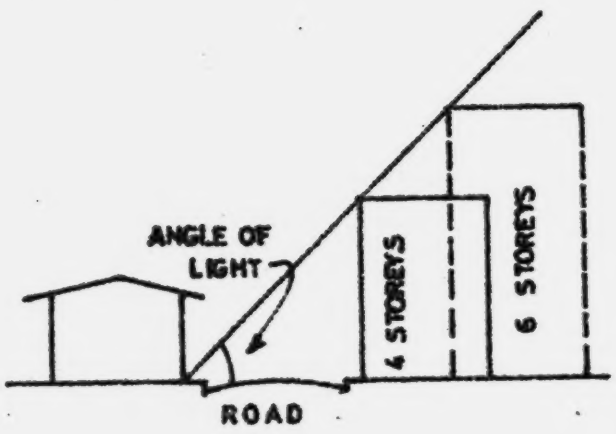
It is considered that lifts need not be installed in school buildings up to and including six storeys in height. Four-storey high school buildings without lifts are common

throughout the Region and Hong Kong has a standard type secondary school six storeys high without lifts. It is stated in respect of the Hong Kong school that there are no administrative problems involved and that the school can be cleared quickly and easily and, moreover, that the school is cleared completely at each recess period.

The general comment that young children or elderly teachers cannot be expected to climb six floors may be simply answered by reserving the lower floors in these instances. With this in mind it is suggested that primary schools without lifts should be restricted to four floors.

Other factors which may limit the height of the building are space about the buildings and fire fighting facilities.

FIGURE 1



It is necessary not only to provide adequate space for light and air about the school buildings but also to ensure that these facilities in neighbouring buildings are not adversely affected; the angle of light, therefore, may well limit the height of the building, as shown in Fig.1. The school building can of course be set back from the boundaries but this may not be possible on restricted sites surrounded by narrow roads, without disruption of the space for physical training or games.

The ability of locally available fire-fighting equipment to deal with fires in high-rise buildings should also be carefully considered, as there is a great deal of inflammable material in a school.

5. *When to Build High-Rise schools*

The building cost per pupil place will vary first with the type of school *i.e.* primary or secondary, general or vocational; secondary, with the height or number of storeys; and thirdly, with the size of the school. These variables form one pattern of costs.

However when the total cost per pupil place (*i.e.* the total building cost plus the total land cost) is considered a somewhat different pattern of costs develops. This is brought about first by the varying areas of land required for buildings of varying heights and size and secondly, by the cost of the land.

Thus there is a point at which the cost of the land begins to offset the higher building costs of the high-rise schools, and it is possible to prepare a series of graphs which will indicate the most economical combination of building costs and land costs.

Nevertheless it must be borne in mind that this proposition is formed on the basis of providing the minimum area of land on a sliding scale as outlined earlier. If on the other hand, sites are provided on a standard allotment of say 1 hectare per 1500 students, then the exercise changes in pattern. It is no longer an exercise to determine the most economical arrangement of building costs and land costs, but rather an exercise to determine whether the area of land which becomes available for outdoor activities of the school, through the construction of a high-rise school, justifies the additional building costs.

The total cost (capital cost) per pupil place comprises the following:-

i) Cost of the land.
ii) Cost of developing or clearing the land.
iii) Nett building cost.
iv) Additional (external) works costs.
v) Design costs or departmental charges on items iii & iv.

This can be simply expressed as:-

$$Cp = b + lt + p$$

Where Cp = total cost per pupil place

b = total building cost per pupil place (this includes items iii, iv & v. above)

l = land cost per unit area (includes items i & ii above)

t = area of land occupied by the buildings and the space about the buildings

p = area of land required for the external activities of the school.

i. *Cost of land:* The cost of the land should be the market value and should include all survey and legal charges. If the land is acquired by a government department at the market value and then offered to the education department at something less than its full value, the higher value should be used as this is what government has paid for it and will be paying for the school. There is perhaps an unfortunate tendency to hide some of these costs.

ii. *Cost of developing or clearing the land:* Cost of developing the land may include the demolition of existing building; diversion of roads or services.

iii. *The Nett building cost includes:*

a) the school buildings, including built-in furniture;
b) excavation and levelling for buildings, and recreation areas;
c) the construction of the recreation area and link units between buildings;
d) all contingent sums, insurances etc. in connection with the above.

iv. *Additional work costs:* These are the variable costs associated with the building due to the vagaries of the site and would include:

a) laying of water, gas, electricity mains, wells, sub-stations, sewerage disposal plants;
b) site layout and planting, boundary walls and fences;
c) roads, paths, car parks, hard areas for games;
d) staff quarters, cycle sheds.

v. *Design costs:* Total cost of professional fees for design and supervision of the construction of the buildings, or the departmental charges in respect of this work. The departmental charges can vary from 2% to 18% and more often than not, these charges are not levied (as they should be) on the cost of the building. Unless this is done there can be no proper accounting of school building costs.

The attached graphs have been based on the school costs of a country in the Region - not on actual schools, but on costs derived from a study of the schools and using assumed data regarding sites and size of schools.

The cost index of the relationship of storey heights are given in Table II below. It is relevant to mention that the single-storey buildings used in this particular country are very simple and that there are virtually no circulation areas or partition walls dividing the classrooms, and windows are often excluded. This will account for the sharp increase in costs from one to two storeys at primary level. The difference is less pronounced in second-level schools and this is due to the introduction of specialist-type teaching spaces.

The cost indices are given as an example only for purposes of demonstrating the construction of the graphs at the end of this article.

TABLE II - COST INDICES OF THE RELATIONSHIP OF COST TO STOREY HEIGHTS

No. of storeys	*Primary*	*Second-level General*	*Comprehensive*
1	*100*	*100*	*100*
2	*215*	*147*	*144*
3	*238*	*159*	*150*
4	*247*	*169*	*158*
5	-	*178*	*163*
6	-	*189*	*168*

Example:

A second-level general school of 1680 students with nett building cost per pupil place for single-storey school of 504 cost units* ; if the land has no cost value then the total cost per pupil place will remain at 504 cost units; however, if the land has a value of 325 cost units per square metre the total cost per pupil place will be:

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* Cost unit = unit of currency in the country concerned *e.g.* dollars, rupees, etc.

Total nett building cost	504 cost units
Total land costs	
7.86[4] x 325	2555 cost units
Total cost per pupil place for single storey schools	3059 cost units

Similarly the total cost per pupil place can be calculated for a six-storey building:

Total cost per pupil place with land at *nil* cost value	476 x 1.89
	= 952 cost units

476 = total building cost per pupil place, single storey

1.89 = cost index from Table II

Total cost per pupil place with land value at 325 cost units:

Total building cost	952 cost units
Total land cost 4.11 x 325	1336 cost units
Total cost per pupil place for 6-storey school	2288 cost units

from Table I, made up as follows:

Buildings (3.00 - 6) + 20%	0.60
Physical training	1.66
Science garden	0.20
Recreation area	1.50
Space about buildings 0.60 x 25%	0.15
	$4.11m^2$

[4] from Table I

From this it can be seen that although the cost of the building per pupil place for a six-storey building is considerably greater than for a single-storey building, the total cost per pupil place of a six-storey building is considerably less. A comparison of these two examples is plotted on Graph 2 and indicates the point in land cost values when it becomes economical to build a six-storey school building or, in other words, the point at which the land cost begins to offset the higher building cost. Graphs 3, 4 and 5 give a comparison of costs for first-level and second-level general and comprehensive schools from 1 to 6 storeys. The additional-works-cost has been set at 10% of the nett building cost and the design cost has been set at 8% of the nett building cost plus the additional work cost.

6. *Allocation of Land for Schools*

With regard to the allocation of land for schools there are four possible cases which can be considered:

i. where the high land cost and the scarcity of land justifies a high-rise school building;
ii. where, because of the higher building costs, it may be more economical to purchase more land, than to build a high-rise school;
iii. where the school site has already been fixed and it is possible to ascertain the economical number of students to be accommodated in terms of land and building costs;
iv. where the land has already been alocated, but is too small for the number of pupils to be accommodated, to ascertain the additional area of land required to provide the most economical solution in terms of land and building costs.

It has been suggested that the area of land required to meet the needs of the school can be calculated in much the same way as the area of teaching spaces within the school. However unlike the school building where the area of teaching space can be precisely controlled, it is not always possible to acquire a precise parcel of land.

In a redevelopment area there is the possibility that a precise area can be set aside for the school, but even at the planning stage it is not practical to subdivide land with such precision.

Consequently what would be the situation where, for example, 1 hectare (2.4 acres) of land is set aside for a school? If the view is taken that a school of only 1500 pupils is required then the propositions expounded in this paper fall flat and perhaps it could be left to the whim of the designer to choose whether he erects a two- four- or six-storey building on the site! If, on the other hand, there is a clear indication that single-storey buildings cost less to construct than multi-storey buildings (and there is every indication that this is so) then it does not appear sensible to construct multi-storey buildings on a site where sufficient land remains for all other school activities after land has been taken for single-storey building.

An alternative method of approaching this theoretical situation would be to establish how many students can be accommodated on the land. With 1 hectare of land set aside for the school it is a simple matter to establish first, the size of the school and, secondly the most economical combination of land cost, building cost and height of the building.

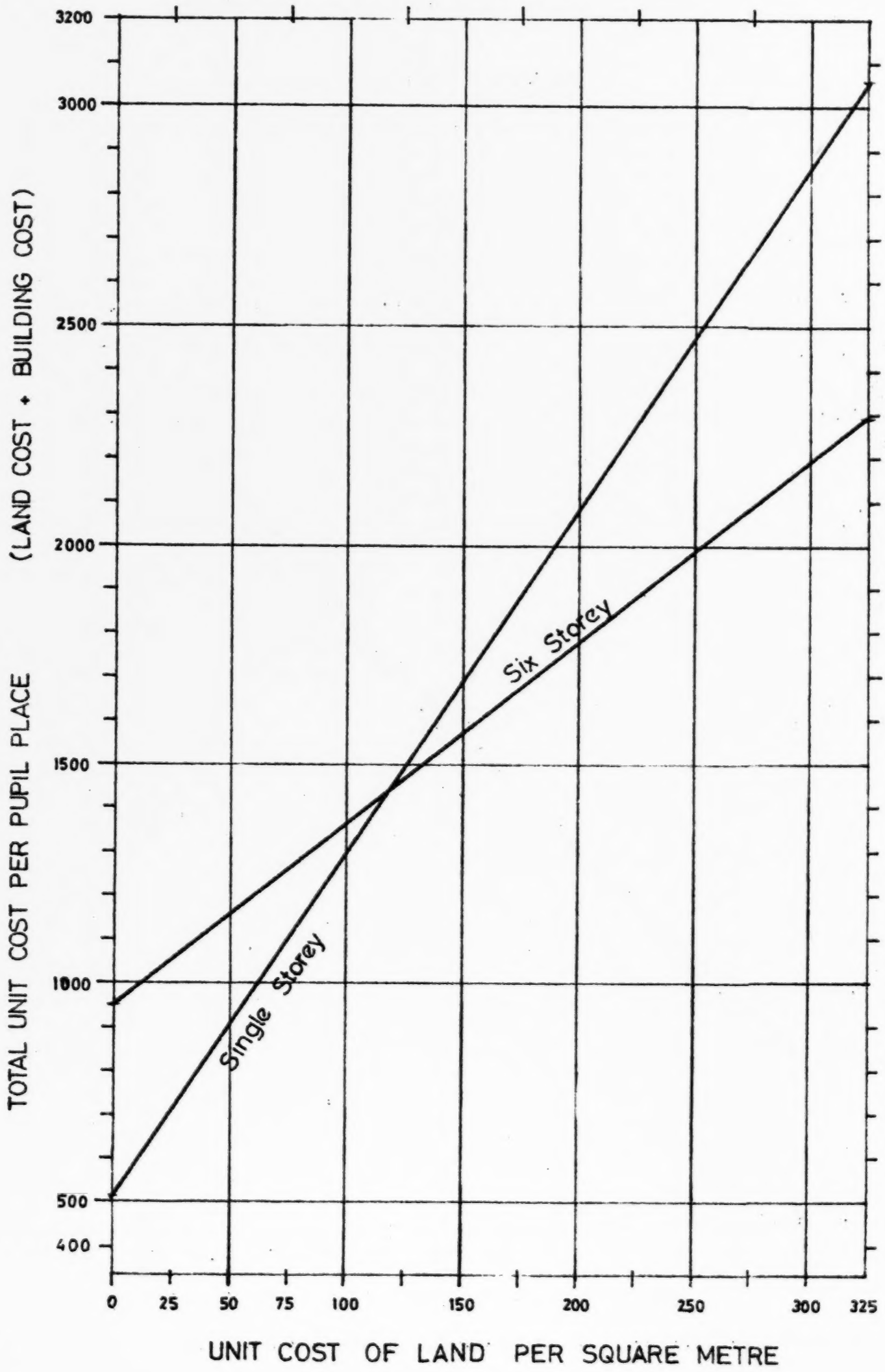
Assuming that the total land cost is 150 cost units per m^2 and the school under consideration is a second-level general school then reference to Graph 4 indicates that a four-storey building is the most economical solution. Reference to Table I shows that the total area of land required for a 4-storey building is $4.48m^2$. Thus the number of pupils that can be accommodated on the land is:-

$$1 \text{ hectare } (2.47 \text{ acres}) = \frac{10{,}000^2}{4.48} \approx 2300 \text{ pupils.}$$

This means in this particular instance that if a school for only 1500 pupils is required at present, the site has a possible expansion of 50% for the future and it should be possible to locate the buildings at the first phase of the programme to allow for their future expansion.

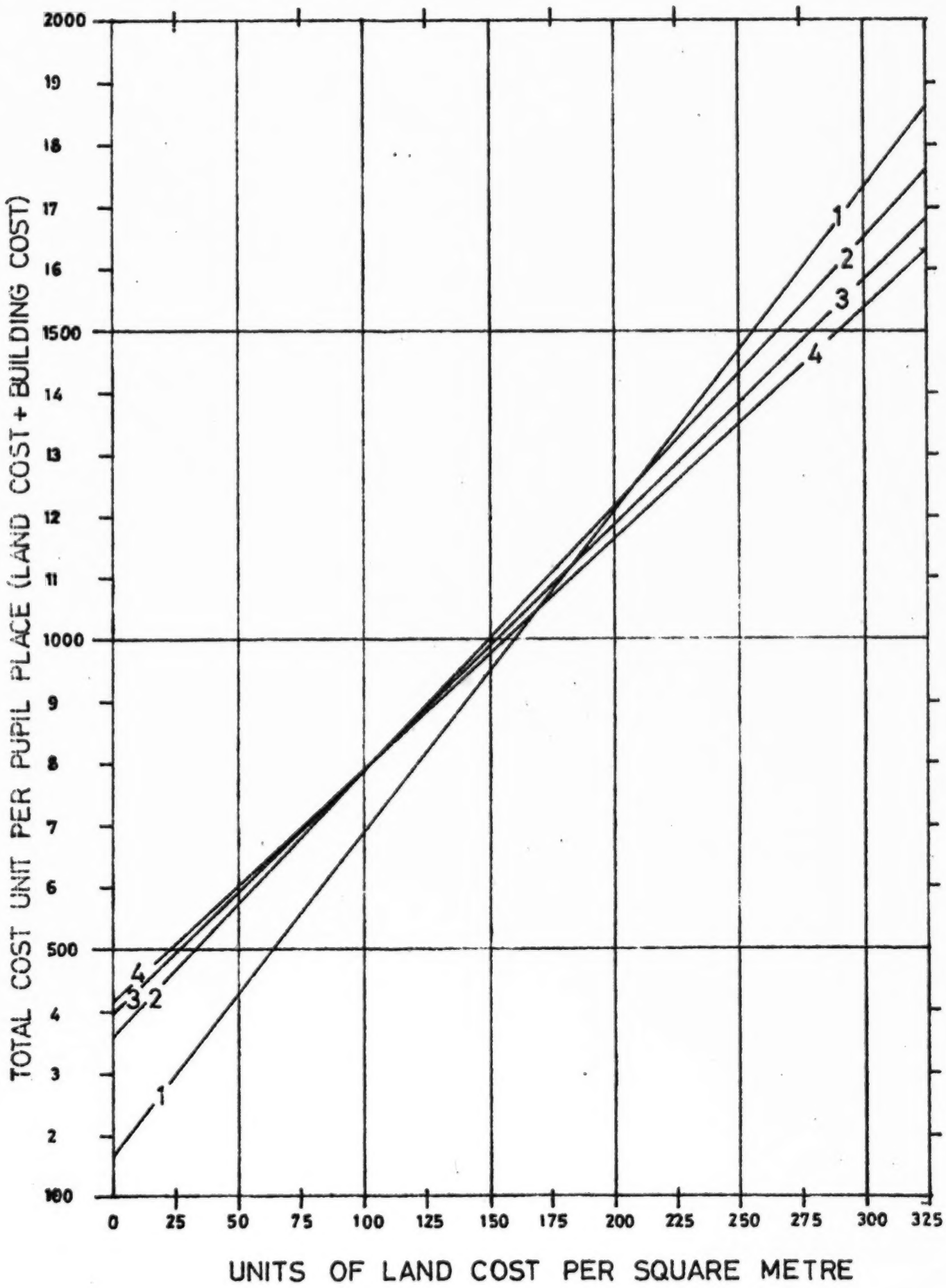
GRAPH- 2

SHOWING ECONOMIC TOTAL COST PER PUPIL PLACE IN RELATION TO STOREY HEIGHTS AND UNIT COST OF LAND PER SQ. METRE



GRAPH—3

SHOWING ECONOMIC TOTAL COST PER PUPIL PLACE IN RELATION TO STOREY HEIGHTS AND UNIT COST OF LAND PER SQ. METRE

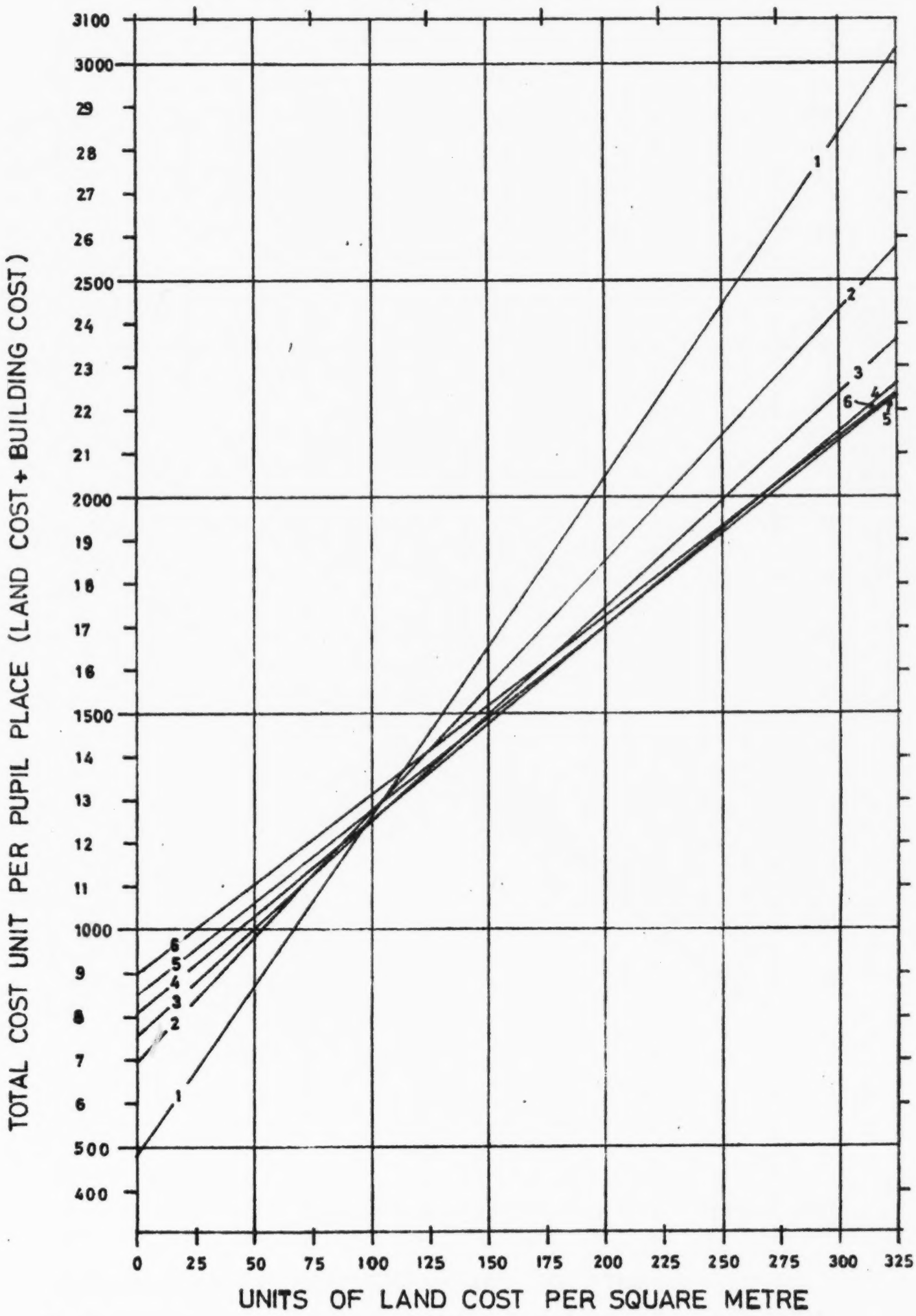


LEGEND ——— 1 ——— Indicates number of storeys. i.e. 1 storey, 2 storey etc.

GRAPH-4

SHOWING ECONOMIC TOTAL COST PER PUPIL PLACE IN RELATION TO STOREY HEIGHTS AND UNIT COST OF LAND PER SQ. METRE

SECONDARY GENERAL

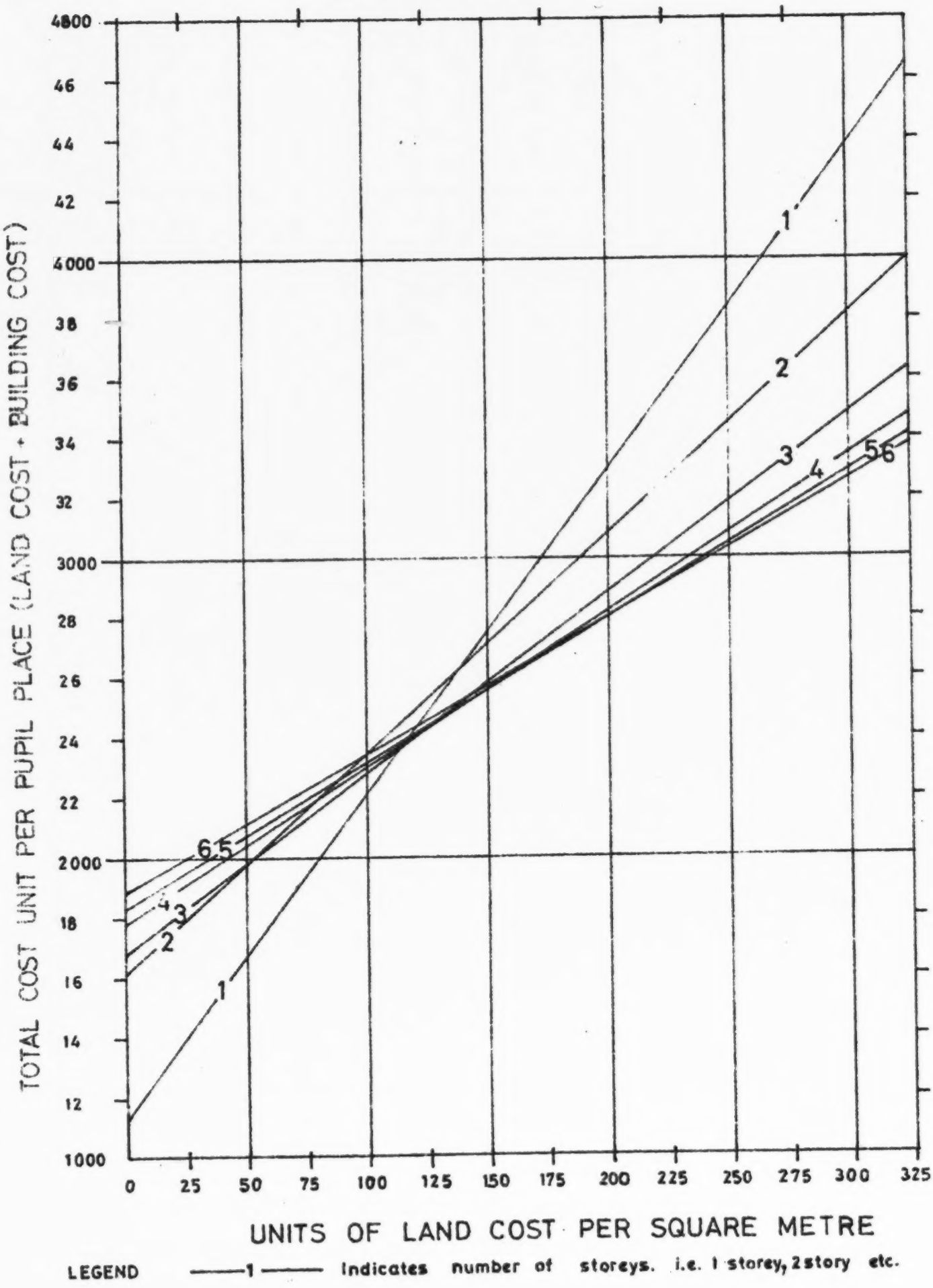


LEGEND ——— 1 ——— Indicates number of storeys. i.e. 1 storey 2 storey etc

GRAPH–5

SHOWING ECONOMIC TOTAL COST PER PUPIL PLACE IN RELATION TO STOREY HEIGHTS AND UNIT COST OF LAND PER SQ. METRE

COMPREHENSIVE



LEGEND ——1—— Indicates number of storeys. i.e. 1 storey, 2 story etc.

III EDUCATIONAL BUILDING ABSTRACTS

Aa7 - EDUCATION

79. PAUL, PETER D. Expressing educational requirements; A I A school plant study BT 1-61. American Institute of Architects. Journal, v.49, no.1(July) 1967, p.71-4, illus., bibl.

Mr.Paul, a partner in a firm of architects and planners, is Chairman of the Educational Facilities Committee of the Baltimore (Maryland, USA) Chapter of the American Institute of Architects. He advocates in this article, the type of collaboration which ARISBR contemplates for development group work in Asia. The study presents the important factors which are sometimes missing in the communication between the educator and the architect prior to the design of educational buildings.

"Educational Specifications" (which could well be called "educational requirements for school facilities") form an initial step in this communication. They analyse the status of the educational system and, implicitly, the public values which guide it. When the new school is constructed these values are translated from words into the spatial language of a building.

Dr.Gardner at US Office of Education urges that faculty members themselves write the educational requirements (specifications) after careful analysis of their programme objectives. He suggests the form which these specifications should take and which include:

i. School philosophy;
ii. General considerations about the total school beyond consideration of its parts;
iii. Consideration of each separate use-area in terms of the following seven points:

philosophy and objectives
activities to be housed
persons to be housed
space needs approximation
functional relationships
equipment
special provision

B - BUILDING AND ARCHITECTURAL MANAGEMENT & PRACTICE

80. FURUKAWA, OSAMU. The Japanese construction industry; III. Japan architect, no.136 (Nov) 1967. p.94-8, illus;, tables.

The status of the architectural profession in Japan is reviewed. The profession is perhaps unique in that it has no unified professional group organisation and the divisions between architecture and engineering are not clearly marked. The registration of architects is, however, carefully controlled by legislative enactment. Registration is in two categories, A & B differentiated only by length of experience: of the 224,472 architects, 176,090 are men and women of longer experience and are therefore in category B.

The article reviews the status of the construction industry and the changes that are taking place notably in the fields of materials, mechanization, costs and industrialisation which, as far as construction is concerned, is well developed.

B37 - BUILDING ECONOMICS

81. NAZEM, SUFI M. Building cost estimation. Building, v.213, no.49 (8 Dec) 1967, p.135-140, tables.

The author introduces statistical theories into the subject of cost planning, thereby allowing the average costs of many similar projects to be used with confidence in the early stages of planning. He offers a guide, clearly illustrated with worked examples, to the setting up of a cost library; nevertheless, he is well aware of the difficulties involved and discusses these at some length. These include the problem of obtaining cost information from official and private sources; the classification of sub-headings or elements; the use of actual costs or percentage values; the choice of variables.

In his paper, for purposes of illustration the author has used a percentage of total cost as a variable or reference indicator instead of the actual cost of a particular element as it has the advantage that it does not require price level adjustment. This is most useful in the early stages of planning and it can easily be translated to actual costs.

Ba7 - BUILDING ECONOMICS (contd.)

81. NAZEM, SUFI M. Building cost estimation. (contd.)

To illustrate the method the author has taken a hypothetical building - a nurses' home - and has assumed that cost information is available for eight nurses' homes under six sub-headings or elements. Details of one such hostel is given in Table I below:

TABLE I - NURSES' HOSTEL, No.1

Element	*Cost $*	*% total cost*
Sub-structure	*1,806*	*6.27*
Super-structure	*12,350*	*42.88*
Internal finishings	*4,067*	*14.12*
Fittings	*1,531*	*5.32*
Services	*8,013*	*27.82*
Site works	*1,033*	*3.59*
	28,800	*100.00*

The eight projects can be similarly expressed and so a distribution of percentage costs can be obtained. Taking the element "Super-structure" as an example, the distribution of the percentage costs are as follows:-

1.	42.88	5.	37.41
2.	50.20	6.	35.90
3.	43.80	7.	44.50
4.	39.41	8.	47.10

The average values of the percentages is denoted by the symbol $\bar{x}$ which has been found from the formula:-

$$\bar{x} = \frac{1}{n} \sum x_i$$

The standard deviation, a measure of dispersion of the percentages around the average value, is denoted by the symbol "s" which has been worked out from the following formula:-

$$s = \frac{1}{n-1} \sum^{n} (x_i - \bar{x})^2$$

Using the formulae average of the percentages

$$= \frac{1}{8} (42.88 + 50.20 + ... + 47.10)$$
$$= 42.65$$

The standard deviation

$$= \frac{1}{7} (42.88 - 42.65)^2 + (50.20 - 42.65)^2 + ... + (47.10 - 42.65)^2$$
$$= 4.86$$

Ba7 - BUILDING ECONOMICS (contd.)

81. **NAZEM, SUFI M.** Building cost estimation. (contd.)

Similarly the average values and standard deviations can be worked out for the other sub-headings.

Statistically the interval between one standard deviation *less* than the mean and one standard deviation *further* than the mean (symbolically $\bar{x} \pm s$) is the important one in the use of cost information for future cost estimating. These intervals can be used as norms and if the estimated value falls outside this interval it can be taken as a warning that it should be re-considered. The two extreme values of the interval may be taken as the upper and lower warning limits. The revised cost reference library is summarised in the following table:

TABLE II - REVISED COST LIBRARY FOR NURSES' HOSTEL

	Sub-Structure	Super-Structure	Internal Finishing	Fittings	Services	Site Works
Average of percentages	7.72	42.65	15.35	4.12	25.88	4.28
Standard deviation	1.66	4.86	2.81	1.58	5.20	2.10
Lower limit	6.06	37.79	12.54	2.54	20.68	2.18
Upper limit	9.38	47.51	18.16	5.70	31.08	6.38

A similar table covering 95% of all projects can be produced by calculating the limits around the mean by adding and subtracting twice the standard deviation ($\bar{x} \pm 2s$). This will provide a second and more critical warning point, as is illustrated in the table given below:

TABLE III - FINAL COST LIBRARY FOR NURSES' HOSTEL

		Sub-Structure	Super-Structure	Internal Finishing	Fittings	Services	Site Works
Lower limit		4.40	32.93	9.73	0.96	15.48	0.08
Upper limit		11.04	52.37	20.97	7.28	36.28	8.48
Now, the final cost library can be compiled from both the tables							
		Sub-Structure	Super-Structure	Internal Finishing	Fittings	Services	Site Works
Average of percentages		7.72	42.65	15.35	4.12	25.88	4.28
First Warning Limits	Lower	6.06	37.79	12.54	2.54	20.68	2.18
	Upper	9.38	47.51	18.16	5.70	31.08	6.38
Second Warning Limits	Lower	4.40	32.93	9.73	0.96	15.48	0.08
	Upper	11.04	52.37	20.97	7.28	36.28	8.48

Ba7 - BUILDING ECONOMICS (contd.)

81. NAZEM, SUFI M. Building cost estimation. (contd.)

The library of cost information can be used in possibly two ways: first, as a cost guide for future estimation; secondly, as a check to any future estimation. To illustrate the first point if, say, £50,000 is to be spent on a projected nurses' hostel, reference to the cost library (Table III above) will show how the total sum should be apportioned to the elements as a percentage of the total, together with the warning limits. These percentage values can be translated into actual cost values as shown in the table below:

TABLE IV - APPROXIMATE BREAKDOWN OF COST (in £)

		Sub Structure	Super Structure	Internal Finishings	Fittings	Services	Site Works
Averages		3.860	21, 325	7, 675	2, 060	12, 940	2, 140
First Warning Limits	Lower	3,030	18.895	6,270	1, 270	10, 340	1, 090
	Upper	4,690	23, 755	9,080	2.850	15. 540	3, 190
Second Warning Limits	Lower	2, 200	16, 465	4,865	480	7, 740	40
	Upper	5,520	26.185	10,485	3,640	18, 140	4,240

The average cost may be taken as a target cost with the first warning limit providing a degree of flexibility to take account of unforseen variables. When the estimates for the sub-headings fall outside the warning limits the causes should be investigated. The total estimated cost should not, of course, exceed the budgeted amount, in this case £50,000. Should this occur, then adjustments to one or all of the estimates for the sub-headings should be made to bring the total estimate within the budget.

The six headings have been used to a reasonable basis for the purpose of explaining the method. To increase the value of the system it will be necessary to sub-divide the main headings. Many organisations have developed a set of cost headings and no doubt anyone of these can be adapted, if need be, to suit a particular purpose.

Ba7 - BUILDING ECONOMICS (contd.)

81. NAZEM, SUFI M. Building cost estimation. (contd.)

However it cannot be overlooked that the basis of this cost planning system and indeed of any cost planning system is cost analysis. With priced Bills of Quantities (or a priced schedule of labour and materials) it is relatively simple to allocate costs to the various subheadings or elements. Without the aid of such documents and where tenders have been based on specifications only it is not so simple usually for the reason that it is difficult to obtain cost information from the contractors in the form required.

Nevertheless the proposals presented by Mr.Sufi M. Nazem are well worth further consideration. They also point to the need for all concerned with building today to become familiar with the work of the statistician.

82. RAO, JAGANATH. Significance of economy in construction. Indian builder, v.15, no.12 (Dec) 1967, p.63-4.

In the inaugural address presented by the Minister of Works, Housing and Supply at the Symposium of Construction Costs held in August 1967 in New Delhi the Minister referred to construction costs as being of national importance in the economic conditions of the country. He said substantial economies are possible by resort to more up to date building codes and specifications, improved designs, use of substitute and locally available materials and standardised construction.

Cost reduction achieved by using poor materials and inferior specification would decrease the expected life of structures and increase the day-to-day maintenance cost, he said and reduction in building cost should be sought by increasing the productivity of men, better use of materials and by proper team work of administrators, planners, architects, engineers and contractors.

The Minister stressed the need to provide sufficient time to architects and engineers to work out alternative designs and try out new ideas to produce the best solution.

Ba7 - BUILDING ECONOMICS (contd.)

82. **RAO**, JAGANATH. Significance of economy in construction. (contd.)

He commented on the need for training of the craftsmen and of the technicians in charge of works and referred to the various in-service training courses now established which focussed attention on the various factors needing special attention to increase the efficiency of building.

The Minister also made reference to the engineers and architects as being conservative and not receptive to new ideas and techniques which are being used in developed countries. He pointed out that as they were responsible for buildings which last for many generations it was understandable for the architects and engineers to "play it safe". It is, however necessary, he went on to say that new techniques should be tried out experimentally on a pilot scale before adopting them for large scale construction programmes. In this connection the Minister welcomed the scheme for experimental housing initiated by the National Buildings Organisation whereby a grant of 75% is given to any State government or Central Government Agency for the construction of experimental buildings, using new building materials and advanced construction techniques. The full amount will be reimbursed by the Ministry of Housing in case of failure of the experiment. This scheme should give encouragement to those who are anxious to try out new ideas and materials and latest construction techniques.

A report on the above symposium is also contained in this same publication.

(2) - FUNCTIONAL ELEMENTS

83. CONCRETE in detail. Progressive architecture, v.48, no.10 (Oct) 1967. p.132-161, illus.

The articles take the form of a series of discussions by specialists in the design and manufacture of both in-situ and pre-cast concrete elements, and in addition there is a series of drawings illustrating the use of the material and fixing details. The specialists do not agree on all points, particularly on the use of performance specifications and the use of local or imported (*i.e.* other than local) aggregates. The first would seem to hinge around the know-how and competence of the manufacturer and the second around an intimate knowledge of sources of aggregate throughout a country or district, its cost at source and transport costs.

(2) - FUNCTIONAL ELEMENTS (contd.)

83. CONCRETE in detail. (contd.)

The specialists offer some sound advice on how the design of the panels or units affects the cost of the mould and on programming and ordering and how they affect production costs. They also discuss the responsibility of the design of reinforcement and suggest that where the unit is designed as a structural member, the engineer should size and locate the bars. Where the function of the reinforcement is to strengthen the unit itself, to control cracks and to facilitate manufacture and handling, then the manufacturer should assume responsibility.

Much of the criticism and disappointment arising from the use of concrete as a finished product and a material in its own right would seem to stem from a lack of understanding of the material in such matters as the influence of the size of the aggregate on detailing; the preparedness to accept variations and slight imperfections natural to the material as for natural stone; the neglect to provide traditional weathering devices such as drip moulds. The specialists also make some pertinent comments on the use of exotic and expensive exposed aggregate the texture of which is lost, more often than not, through ignoring the scale of the project and the distance between the viewer and the building.

84. HENDRY, A. W. High-rise load-bearing brickwork. Building, v.213 no.40 (6490), (6 Oct) 1967, p.144, 147-8.

This article is an extract from a lecture given in July 1967, by Professor Hendry of the Department of Civil Engineering, University of Edinburgh.

The cost advantages of load-bearing brick structures are great inasmuch as brickworks itself also provides subdivision of space, thermal and acoustic insulation, fire and weather protection. As a material it is cheap but durable and can be constructed without enormous capital investment on the part of the builder.

Classifications of wall arrangements may be put into three rough headings:

a) cellular walls;
b) simple or double cross-wall systems;

(2) - FUNCTIONAL ELEMENTS (contd.)

84. HENDRY, A. W. High-rise load-bearing brickwork. (contd.)

c) complex arrangements.

The importance of lateral support of such buildings is stressed and foundation requirements do not present unusual problems.

Comparative cost tables and construction types illustrate useful information for buildings from 5 to 15 storeys.

(4) - FINISHES

85. SYKES, CHRISTOPHER. Child-proofing. Building materials (Lond), Nov. 1967, p.43-5, illus.

In growing up, children require buildings which can resist heavy wear. One of the most important items in this connection is the working surface which may be either a table-top or the floor. It is suggested that for tables laminated plastics are superior to most other materials in resisting cutting, the action of water and other liquids, marking and other hazards that result from a child both at work and at play. Children do not respect automatically materials which are designed for luxury appearance and it is important that in any area occupied by children, up to five feet above the floor should be constructed in durable and resistant materials. Floors need to be designed with care and linoleum, pvc or thermoplastic products are found to resist abrasion, heavy wear and certain stains rather better than other materials.

(87) - SPACES & FIXTURES FOR EDUCATIONAL BUILDINGS

86. NAYLOR, GILLIAN. Furniture for the secondary school. Design, (Lond) no.226 (Oct) 1967, p.28-34, illus.

By using the services of the new furniture-producing consortia, local authorities are beginning to solve the many problems involved in school furniture design. This report is one of a series, the first being on primary school furniture (Design no.222, abstracted in Buildings for Education v.1, no.4, item 48).

(87) - SPACES & FIXTURES FOR EDUCATIONAL BUILDINGS (contd.)

86. NAYLOR, GILLIAN. Furniture for the secondary school. (contd.)

The Development Group of the Department of Education and Science has recommended the construction of specially designed 5th and 6th form centres that can be erected within existing building complexes. New teaching methods; the raising of the school leaving age to 16 in 1971; the need for storage space and specialized work surfaces in classrooms; all these are contributing to the need for simple solutions to a complex problem as quickly as possible.

To accomplish these tasks, authorities have assigned study and development to the Counties Furniture Group (chairs, benching, seating, study bays); the Nuffield Foundation (storage in science laboratories); the Department of Education and Science itself (mobile storage trolleys related to worktop heights); and others. The results of some of their work are well-documented and illustrated here.

(97) - EDUCATIONAL BUILDINGS

87. BANERJEE, A. C. *and* SRIVASTAVA, R. D. Research on school building at C.B.R.I. Indian builder, v;15, no.12 (Dec) 1967, p.91-5, illus., bibl.

In India's 4th Five-Year plan an attempt has been made to link education more directly with the country's development programmes. In quantitative terms an increase in the enrolment of children in primary schools from 48 to 69.5 million is planned and in junior high schools from 11 to 19 million. This great expansion of the school-going population by 1981 will require 1800 million square feet of covered area.

Economy in the cost of construction is of the very greatest importance in connection with a programme of such magnitude and the Central Building Research Institute, Roorkee, has, with this in mind, commenced a research programme on school buildings with a view to providing design data and methods of cost reduction for schools.

(97) - EDUCATIONAL BUILDINGS (contd.)

87. BANERJEE, A. C. *and* SRIVASTAVA, R. D. Research on school building at C.B.R.I. (contd.)

The programme includes anatomical studies of the body-sizes of children, studies of teaching spaces, storage requirements, quality studies, organisation studies, site-development studies and investigation into the effective planning and utilisation of services and their contribution to health and physical environment.

The article briefly outlines the progress to date in these fields.

88. ESCUELA nacional primaria urbana tipo 7 aulas, Cuba[Urban national primary school, project type 7 classrooms, Cuba]. Conescal 7 (Aug) 1967, p. 647-50.

This project by the Ministry of Education, Cuba, is for the construction of primary schools each with a capacity of 264 pupils per shift. There are six elementary school grades and one pre-school grade provided for in these new buildings. The project is of interest because the curriculum includes the concept of a classroom workshop. The building is designed in two blocks - one of classrooms and the other containing a library and pre-school area. The blocks are joined together by common facilities such as toilets. Each classroom is of $60m^2$ and the pre-school classroom has its own sanitary unit. The construction of the building is of beams and columns, all of which are pre-fabricated and designed to standard measurements of 6 metres. The in-filling walls are of mud brick, exposed internally and externally and there are concrete floors and metal doors and windows. The need for good cross ventilation was an important design consideration.

89. EVOLUTION of the primary school; collaboration at Manchester. Architects' journal, v.146, no.6 (9 Aug) 1967, p.345-7, 349-50, illus.

As a sequel to a study of primary school furniture, this is a report on the application of the new furniture to the Armitage County Primary School, Gorton, Manchester, England. It was designed jointly by the City Architects Department and the Architects and Building Branch of the Department of Education and Science.

(97) - EDUCATIONAL BUILDINGS (contd.)

89. EVOLUTION of the primary school; collaboration at Manchester. (contd.)

In designing this school a new form of collaboration between central and local government was introduced. The local government offered the use of one of their programmed schools as the first setting for the range of furniture resulting from the original study. This form of collaboration has proved a useful combination of experience.

The school in residential surroundings, was designed for 310 children from age 3 to 11. The plan is developed from a core of Hall and Kitchen services with four age-groups in very flexible areas at the four corners. These units are for 80 pupils each, supervised by 2 teachers, and incorporate a variety of activity groupings and furnishings. They each have their own entrance and outdoor activity ground and the school is accessible from the residential area by pedestrian ways. The article is illustrated, describes the furniture and gives an outline of costs.

90. EXPERIMENT in education; flexible plan for Oadby High School. Architects' journal, v.146, no.22 (29 Nov) 1967, p.$346-7.

The Leicestershire Education Authority has completed a new high school for 720 boys and girls between 11 and 16 years of age, using a plan type previously confined mainly to primary schools. This, of course, involves the replacement of the conventional classrooms by larger flexible teaching spaces grouped around a library/resource area.

The motive behind the design of the new school is the absence of the qualifying examination before the 14 year-olds move on to the next stage of secondary education. This has given the Education Authority the chance to reconstruct the basic educational patterns and to bring into play comprehensive educational methods. The implications of the new design are that education is more a learning, than a teaching, process and children in the school are encouraged to work at their own pace and to use those educational aids that they find most suitable for their own purposes.

The article is well illustrated.

(97) - EDUCATIONAL BUILDINGS (contd.)

91. INSTANT schools in American; entire campus built for relocation. Industrialised building system & components. v.4, no.11 (Nov) 1967, p.61-73, illus.

The article describes the rapid construction of a junior college for nearly 2000 students. The speed of construction was such that the entire building was completed in 74 days. It has been designed in such a way that in 5 years' time the pre-fabricated elements could be disassembled and the building moved to a new site to be allocated to the school at a future date.

The building is one of 19, specially prefabricated and constructed of stress-skinned panels. The exterior wall is $\frac{3}{8}$" plywood impregnated with a glass-fibre coating. This forms the outside of a double facing behind which is a glass-fibre insulating blanket and on the interior is a $\frac{3}{8}$" ply sheet covered with $\frac{1}{8}$" in composition board and a heavy vinyl panel.

The roof is of tongued and grooved plywood, fastened to tubular steel beams. The floor which is also of plywood is $1\frac{1}{8}$" thick.

92. STEPHENSON, GORDON. The physical planning of universities,
BIRRELL, JAMES. Neighbours on the campus; planning at St.Lucia and Townsville,
HARRISON, G. J. The planning of Bedford Park; Adelaide's second university,'
ABRAHAM, WALTER *and* JACKSON, MAX. Sydney University development as a case study in urban renewal. Australian Planning Institute. Journal, v.3, no. 5(July) 1965, p.147-162, illus.

The case for integration of new universities with new cities is argued both from the economic and cultural viewpoints. The present practice of locating universities and schools on cheap ground, far from the city centre imposes heavy recurrent costs in transport and adds a burden to already overcrowded transport systems. The rôle of the city centre as a social focus is no longer capable of fulfilment and the location of a new university in the city can do much to re-stimulate social integration on the metropolitan scale.

Nevertheless a university plan is not finite; it must go on developing and expanding. Land given for new universities must allow for continuous growth. The articles discuss these concepts with reference to Australian and other university development plans.

(97) - *EDUCATIONAL BUILDINGS (contd.)*

93. TWO fifth-form units at Newport Secondary Modern School and Maiden Erlegh Secondary Modern School. Architects' journal, v.146 no.6 (9 Aug) 1967, p.351-61 *and* 363-4.

These two pilot projects represent comparative solutions to the problems which local U.K. authorities will have in providing an educational bridge into the adult world for the thousands of pupils who will be staying on in 1971 when the leaving age is raised to 16.

The most common need will be to provide accommodation for 15 year-olds attached to an existing secondary school. Educational recommendations for this type of facility were first, that every effort should be made to emphasize the status of the older pupils both through organisation and design of the school and, secondly, that attention should be paid both to imaginative experience through the arts and to personal and social development of the pupils.

The solutions presented show an arrangement of teaching facilities around a common core of social and dining accommodation on which a whole 5th form community could be based. One is within a single storey scheme while the other has two storeys. The article is illustrated and includes a comprehensive description of materials, unit costs, cost per square foot and metre and a useful commentary on costs.

(98) - *RESIDENTIAL BUILDINGS*

94. RESIDENTIAL hall for university students. Far East architect & builder, Jan. 1968. p.27-32. illus.

This Hall of Residence has been built to house 125 students of the University of Hong Kong and provides studying and dining facilities for an additional 200 non-residential students. The building is multi-storied and on quite a small site. Individual student accommodation has been provided at 80 sq.ft. per student for studying and living. Students are grouped from 8 to 10 per corridor which provides a horizontal rather than a vertical social unit. As is the case in most building sites in Hong Kong the ground is sloping and advantage has been taken of this to ensure that no student climbs more than two or three floors to his room from a gallery entrance. Attention has been paid to orientation to exclude the low afternoon sun; no windows look west. The building is constructed of reinforced concrete cross walls, beams and slab on spread footings.

AUTHOR/TITLE INDEX

Note: Numbers refer to abstracts and are continued on from vol.2, no.1

ABRAHAM, Walter, 92

BANERJEE, A. C., 87

BIRRELL, James, 92

BUILDING cost estimation, 81

CHILD-PROOFING, 85

CONCRETE in detail, 83

ESCUELA nacional primaria urbana tipo 7 aulas, Cuba, 88

EVOLUTION of the primary school; collaboration at Manchester, 89

EXPERIMENT in education; flexible plan for Oadby High School, 90

EXPRESSING educational requirements; A I A school plant study BT 1-61, 79

FURNITURE for the secondary school, 86

FURUKAWA, Osamu, 80

HARRISON, G. J., 92

HENDRY, A. W., 84

HIGH rise load-bearing brickwork, 84

INSTANT schools in America; entire campus built for relocation, 91

JACKSON, Max, 92

The JAPANESE construction industry; III, 80

NAYLOR, Gillian, 86

NAZEM, Sufi M., 81

NEIGHBOURS on the campus; planning at St.Lucia and Townsville, 92

PAUL, Peter D., 79

The PHYSICAL planning of universities, 92

The PLANNING of Bedford Park; Adelaide's second university, 92

RAO, Jaganath, 82

RESEARCH on school building at C.B.R.I., 87

RESIDENTIAL hall for university students, 94

SIGNIFICANCE of economy in construction, 82

SRIVASTAVA, R. D., 87

STEPHENSON, Gordon, 92

SYDNEY University development as a case study in urban renewal, 92

SYKES, Christopher, 85

TWO fifth-form units at Newport Secondary Modern School and Maiden Erlegh Secondary Modern School, 93

SUBJECT INDEX

Note: Numbers refer to abstracts and are continued on from vol.2, no.1

ARCHITECTURAL profession
    Japan, 80

BRICKWORK
    Loadbearing, 84

BUILDING industry
    Japan, 80

CENTRAL Building Research
    Institute, Roorkee,
    India, 87

CONCRETE, 83

COST control, 81, 82

COST planning, 81

DEVELOPMENT GROUPS, 89
    see also EDUCATIONAL requirements
        SCHOOL buildings
            Planning
                Collaboration
                by governments

EDUCATIONAL building research
    India, 87

EDUCATIONAL requirements, 79

FINISHES, 85

FLOORS
    Finishes, 85

FUNCTIONAL elements
    Concrete, 83

FURNITURE
    Secondary schools, 86

PRIMARY schools
    Cuba, 88
    Gt.Britain, 89
    Urban, 88

SCHOOL buildings
    Demountable, 91
    Planning
        Collaboration by governments, 89
    Prefabricated, 91
    Research see EDUCATIONAL building research

SCHOOL furniture
    see FURNITURE

SECONDARY schools
    Fifth form
        Gt. Britain, 93
    Gt.Britain 90

TABLE-TOPS
    Finishes, 85

UNIVERSITIES
    Planning
        Australia, 92

UNIVERSITY buildings
    Student residences, 94

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